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**A GEOGRAPHICAL PERSPECTIVE ON
THE NATURAL GAS SUPPLY INDUSTRY
IN THE UNITED KINGDOM**

by

Keith Chapman

SNF Project No. 4486
Økt bruk av gass innenlands

Kontaktperson: Grete Rusten, SNF
e-mail: Grete.Rusten@snf.no

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1. INTRODUCTION

Natural gas has, over the last 40 years, come to account for a substantial percentage of primary energy consumption (i.e. including inputs to electricity and heat generation) in the United Kingdom (UK). In 2002, this percentage (37.3) was exceeded in only two other European countries, the Netherlands (46.0) and Hungary (43.0) (International Energy Agency, 2003). Although oil has generally attracted greater attention than natural gas, the effects of the latter upon the energy economy of the UK have, in certain respects, been more profound. Most North Sea oil production is exported directly from the UK (69.4 per cent in 2003 (DTI, 2004)) and the balance has been processed within an oil refining system originally established to handle imported oil. By contrast, the availability of natural gas from the North Sea from the mid-1960s transformed the UK gas industry from a producer of secondary energy (i.e. town gas manufactured from coal and oil) to a distributor of primary energy. This transformation had a geographical dimension evident in the contrast between the essentially local distribution systems of the town gas industry and the national system created to deliver natural gas.¹ The development of this system has been accompanied by very significant organisational changes as the gas industry became one of several network utilities transferred from public to private ownership in the UK since the 1980s. This paper reviews these events from a geographical perspective. It is divided into three main sections. The first describes the growth of the natural gas consumption in the UK. The second places this empirical material within a policy framework. The third relates spatial variations in the availability and cost of natural gas to patterns of economic development and welfare.

2. NATURAL GAS IN THE UNITED KINGDOM

The significance of natural gas in the UK is reflected in aggregate trends in production and consumption (section 2.1) and in the evolution of the pipeline network for its distribution (section 2.2).

1.1 Production and Consumption

The rate of growth in primary energy consumption² in the UK has been modest over the last 30 years or so (fig.1), reflecting the changing structure of the economy and improvements in the efficiency of energy use (DTI, n.d.). This gradual increase, however, conceals some fundamental changes in the geographical sources of energy supplies and in the relative importance of different fuels. In 1980, the UK switched from being a net importer (since World War II) to a net exporter of energy as a result of developments in the North Sea (fig. 2).

Natural gas was introduced to the UK energy market in 1964 in the form of imports of liquefied natural gas (LNG) from Algeria. Coincidentally, the first gas discovery in the UK sector was made in the following year and the first supplies from the North Sea were landed in 1967. Levels of natural gas consumption increased dramatically in the early 1970s (fig. 3) as the distribution infrastructure was established. Its share of primary energy consumption rose accordingly to reach 15.9 per cent by 1974, ten years after its introduction (fig. 4). This share increased only gradually in subsequent years until the early 1990s when the construction of several gas-fired power stations (see section 4.2) increased demand to the point in 1996 when, for the first time, natural gas replaced petroleum as the most important source of primary energy. By 2003, natural gas accounted for 40.6 per cent of primary energy consumption compared with 31.8 per cent for petroleum (fig. 1) (DTI, 2004). Most forecasts acknowledge increasing dependence upon imports (see Energy Contract Company, 2004; Hc. 134, 2002; Kemp and Stephen, 2001; Transco, (2004a),³ but Transco (2003a, 4) predicts the share of natural gas in primary energy consumption will reach 46 per cent by 2010.

This upward trend can only be understood by disaggregating the natural gas market into its component sectors (fig. 3). Natural gas rapidly penetrated the domestic market as the national transmission system (NTS) expanded to reach all of the major population centres by the mid-1970s (see section 2.2.). Coal and oil were challenged and natural gas increased its share of this market from 21.6 per cent in 1973 (Department of Energy, 1975) to 69.2. per cent by 2003 (DTI, 2004). The underlying rate of growth in the domestic sector has, however, fallen to less than 2 per cent per

annum in recent years as the market of households with access to gas supplies (see section 4.1) has become saturated (Transco, 2003b). Historical growth in the industrial and commercial sectors has been driven by the overall performance of the national economy and by the substitution of gas for other fuels, notably oil. In general terms, the pattern has been similar to the domestic market with rapid initial penetration followed by stabilisation. Thus natural gas accounted for 14.9 per cent of final energy consumption by industrial/commercial users in 1973 (Department of Energy, 1975); the corresponding figure for 2003 was 43.6 per cent (DTI, 2004). Energy consumption in manufacturing has fallen since the mid-1970s, reflecting the impact of de-industrialisation and the rise of the service sector. Nevertheless, the industrial market for gas, remains bigger than the commercial market. Recent growth has been driven by the emerging power generation market which has been almost exclusively responsible for the rapid increase in natural gas consumption over the last 10 years (fig. 3) (see section 4.2).

2.2 Transmission and Distribution System

The rapid penetration of natural gas into the UK energy market required the construction of pipeline networks to deliver the gas from the reception terminals. The origins of the onshore network lie in the local and regional systems established by the pioneers of the town gas industry in the 19thC (Odell, 1968). These systems have been incorporated within the distribution networks (DNs) which account for over 97 per cent of the 275,000 kms of gas pipelines owned and operated by Transco.⁴ The remainder of the network is made of the high pressure NTS which links the DN's to the coastal terminals.⁵ Gas is pushed through the NTS by strategically placed compressor stations and delivered to eight lower pressure DN's serving different areas of the UK as well as directly to a few large industrial consumers and power stations.

Although consumers obviously rely on the effective integration of the DN's and the NTS, it was the establishment of the latter which was critical to the transformation of the UK gas industry from its historical association with civic ownership and enterprise to one which is truly national in its scale of organisation and pattern of distribution. This transformation was initiated by the imports of Algerian LNG which were distributed via a specially constructed transmission system to most of the major urban

markets in England. It was progressed with the introduction of supplies from the North Sea in 1967 and more or less completed with the establishment of a national pipeline network by the late 1970s (fig. 4). This transmission network developed with reference to the key inputs to the system at the coastal terminals and the principal centres of consumption along the London-Birmingham-Manchester corridor. The relative contributions of the various terminals and, therefore, the disposition of flows of gas within the NTS have changed over time. Algerian LNG was initially supplemented and then displaced by supplies from the southern North Sea channelled via terminals at Bacton, Theddlethorpe and Easington (fig. 4). The timing of conversion to natural gas was broadly related to distance from these terminals. In Scotland, for example, it was not until 1975 that the switch to natural gas was completed. The orientation of the NTS towards the English east coast terminals was altered with the introduction in 1977 of supplies from the northern North Sea via the St. Fergus terminal in Scotland. St. Fergus is the major input to the NTS, accounting for 34.7 per cent of supplies from the North Sea in 2003, followed by Bacton (21.6 per cent), Teesside (14.6 per cent), Barrow (10.9 per cent) and Theddlethorpe (9.4 per cent) (DTI, 2004). These terminals and the pipeline infrastructure of the NTS provide the physical framework to the growth of natural gas in the UK, but this growth has also been significantly influenced by public policies which have shaped the regulatory framework.

3. PUBLIC POLICY AND THE GAS SUPPLY INDUSTRY

The development of the natural gas supply industry has been influenced by public policies operating at different levels. First, energy policy has mediated its relationship to other competing fuels (section 3.1). Second, the operating environment of the industry has been radically altered by the political decision to transfer ownership from the public to the private sector (section 3.2). Third, this transfer has, as a result of detailed aspects of its implementation relating to the transportation of gas, increased the significance of spatial factors in shaping prices and costs (section 3.3).

3.1 Energy Policy

The importance attached to energy as a strategic policy concern has changed with the political complexion of successive UK governments. The current Government defines its energy policy objectives in the following terms – “to ensure secure, diverse, sustainable supplies of energy at competitive prices” (DEFRA/DTI, 2001, 16). Upon reflection, these aspirations contain contradictions that are difficult to reconcile. ‘Competitive’ presumably means ‘low’ prices, but cheap energy is not necessarily consistent with the promotion of efficiency and sustainability in energy use. In practice, the approach to energy policy in the UK has been essentially *ad hoc* and this has been reflected in changing views on the appropriate mix of fuels. The discovery of North Sea gas was perceived as an opportunity in a 1967 White Paper (Cmnd. 3438, 1967), although the scale of the reserves remained uncertain. Following the 1972/73 oil crisis, the magnitude and longevity of these reserves became a major concern reflected in the imposition of depletion strategies designed to extend their productive life, in restrictions on the use of gas for electricity generation, and in a renewed commitment to coal (Department of Energy, 1977). This commitment was reversed in the 1980s when the coal industry declined rapidly as a result of political moves to break the power of the National Union of Mineworkers and to replace coal as the principal fuel in electricity generation. By the 1990s, environmental concerns had become more prominent considerations as the concept of “ a low carbon economy” was linked to the achievement of treaty obligations to reduce atmospheric emissions from combustion processes (Cm. 5761, 2003). These obligations have encouraged rapid growth of natural gas use in electricity generation because of its ‘clean’ burning qualities relative to coal and oil (see sections 2.1 and 4.2). Overall, energy policy has provided an indicative rather than a prescriptive context to the development of the natural gas supply industry in the UK. Much more direct effects have stemmed from privatisation policies introduced in the 1980s.

3.2 Privatisation, Regulation and Competition

Privatisation, defined as the transfer of at least part of the operations of a state-owned enterprise to private control, has been one of the most important and contested economic policy agendas in the UK. Its impact has been felt across various sectors of the national economy including telecommunications, transport and energy. Privatisation derives its intellectual inspiration from neoliberalism which itself rests upon philosophical foundations emphasising the importance of individual liberty, a belief in the concept of the 'free' market and a desire to minimise the role of the state in society. Unfortunately, it is difficult to reconcile these principles with the natural monopoly characteristics of public utilities based upon network structures for the delivery of services to dispersed consumers (see Shaw, 2000). In the case of the gas supply industry, for example, the construction of a duplicate pipeline transmission system to compete with the existing network would be irrational, not least because average costs fall as pipeline networks are used for greater throughput. However, the assumption that competition could only be introduced to public utilities such as gas by building a second network was challenged by developments in information technology which made it possible for different companies to use the same pipes by tracking flows of gas through the system and by recording deliveries to specific consumers. The realisation of these technical possibilities has been far from straightforward and there has been a strong element of trial and error in the UK experience of gas privatisation (see Waddams Price, 1997; Weir, 1999).

Competition in gas supply was, in theory, introduced by the 1982 Oil and Gas Enterprise Act which allowed independent gas suppliers (i.e. oil companies with gas reserves in the North Sea) access to the NTS. The statutory imposition of a third party carriage obligation on the state-owned British Gas Corporation (BGC) was a significant step which anticipated later developments in onshore gas transportation (see section 3.3). BGC was privatised in 1986 as a fully vertically integrated company involved in the production, distribution, storage and supply of gas. The new company, British Gas Plc (BG) remained owner of the pipeline network as privatisation replaced a state by a private monopoly. In these circumstances, it is not surprising that independent gas suppliers, frustrated in their attempts to take advantage of the third party carriage opportunity introduced in 1982 by unreasonably high charges for

access to the NTS imposed first by BGC and then BG, and large industrial consumers, unhappy with apparently discriminatory pricing policies revealed by variations in charges for gas at the different plants of multi-site companies⁶, argued that privatisation had created a fundamentally flawed, non-competitive structure contrary to the public interest. These arguments have underpinned successive attempts to create organisational structures and regulatory frameworks better able to deliver the neoliberal objective of 'free' market competition. These evolving structures and frameworks have been shaped by the intervention of various instruments of competition policy in the UK including the Office of Fair Trading, the Monopolies and Mergers Commission and, latterly, the Competition Commission. The chronology of regulation surrounding the operations of the privatised gas supply industry in the UK is summarised in table 1. The details of the bureaucratic responsibilities of the various agencies are, in a sense, less important than the lack of stability suggested by the frequent changes. These draw attention both to the experimental nature of the exercise and also to one of the great paradoxes of privatisation in the UK – the replacement of the direct state influence of public ownership by indirect influence exerted through various agencies responsible for establishing and enforcing the 'rules of the game'. Furthermore, the participants in the game have been engaged in a continuous re-negotiation of its rules, prompting some critics to question the ability of this regulated market to deliver optimal outcomes (see Stern, 1997; Bower, 2003). Nevertheless, there is no doubt that privatisation had succeeded in increasing competition in the supply of gas by the mid-1990s, mainly as a result of the enforced break-up of the vertically integrated operations of the privatised BG inherited from its state-owned predecessor (BGC).

The 1995 Gas Act was decisive in achieving this break-up by formally splitting the gas supply industry in the UK into three elements: transporters are owners/operators of pipeline systems; shippers are conveyors of gas and users of these systems; suppliers are marketers of gas to final consumers. Firms performing each of these roles require licenses to operate issued by the appropriate regulator.⁷ A key provision of the 1995 Act accepted that whilst the same firm may operate as a shipper and supplier, the gas transporter must be a legally separate entity. This requirement effectively broke the vertical link between supply and transportation which had been maintained for so long by the state-owned BGC and the privatised BG. Thus BG was

formally de-merged in 1997 with BG (BG Transco from 1999)⁸ responsible for the pipeline network and BG Centrica undertaking shipping and supply. These significant changes in the status of the historic monopolist were accompanied by the entry of new players into the market, notably gas producers, such as Total, Shell and BP, and electricity companies, such as Powergen, npower and GdF. The competitive edge of the producers was based on their supply position, an edge reinforced by the difficulties facing BG which had become locked-in to expensive, long term take-or-pay contracts for gas signed in the 1980s and early 1990s on the assumption that it would retain its monopoly position. The competitive edge of the electricity companies was situated at the opposite end of the supply chain in databases which provided useful market information for targeting potential customers. The opportunities for the new entrants were enhanced by various developments which stemmed directly from the framework established by the 1995 legislation. In particular, a Network Code, defining the rights and responsibilities of all users of Transco's transportation and storage system, was established in 1996 (Juris, 1998). This Code was the first attempt to clarify the principles underlying third party access to the NTS which had theoretically been introduced by the 1982 Oil and Gas (Enterprise) Act. The application of these principles included details of the prices to be charged for transporting gas via the NTS (see section 3.3.). Another important new aspect of competition since 1995 has been the emergence of a spot market, mainly for short-term deliveries from producers to shippers at the coastal terminals which are the entry points to the NTS.

The effectiveness of the structures outlined in figure 5 in facilitating competition may be inferred from recent developments in the two main market segments – industrial/commercial and domestic. The volume of consumption is the essential difference between these segments and this has influenced the way they have developed. Choice between competing suppliers emerged in the industrial/commercial market in the early 1990s, approximately 5 years before the domestic market.

It has already been noted that complaints of discriminatory pricing by BG to large industrial consumers were instrumental in the sequence of events leading to the 1995 Gas Act. Given these complaints, it is not surprising that some consumers, notably combined-cycle gas turbine (CCGT) power stations (see section 4.2) by-passed the

NTS by negotiating deals for gas supply via dedicated pipelines built under arrangements with specific producers. Such arrangements were, however, exceptional and it was not until a series of rulings by the regulator (OFGAS) immediately preceding and following the 1995 Gas Act that BG was forced to relinquish its stranglehold over the industrial/commercial market. These rulings exposed BG to intense competition in this market, the effect of which was magnified by BG's previously noted commitment to unfavourable take-or-pay contracts with North Sea gas producers. In these circumstances, BG Centrica's share of the market fell dramatically to 11.9 per cent by 2003 (Energy Contract Company, 2004, 20).⁹

The larger number of consumers (approximately 18 million households connected to mains gas supply) is itself an obstacle to the introduction of competition in supplying the domestic market. This practical consideration was a factor in the lesser priority attached to this market by OFGAS in driving forward competition. The appropriate regulatory mechanisms were not introduced until 1996 in a trial run in South West England and then nationally in 1998. Even with these mechanisms in place, change has been much slower than in the industrial/commercial market. Householders who have traditionally dealt with a monopoly supplier are less inclined than industrial/commercial consumers to behave in an economically rational manner when presented with unfamiliar alternative suppliers (Waddams Price and Bennett, 1999). This psychological inertia is reinforced by the administrative costs, expressed in new contracts and billing procedures, entailed in switching supplier. By 2003, BG Centrica remained by far the biggest supplier with 61.1 per cent of the market (Energy Contract Company, 2004, 21). The other players in the domestic market (almost entirely made up of electricity/gas utility companies) have very much smaller shares (Powergen ranks second with 11.7 per cent) and this pattern seems relatively stable (Energy Contract Company, 2004).

Trends in prices to consumers provide a basis for an overall judgement on the impact of privatisation and related efforts to introduce regulated competition into the UK gas supply industry. These prices have fallen in real terms (fig. 6) and are lower than in most developed economies (International Energy Agency, 2003). Significant price increases occurred in 2000/01 and again in 2004, emphasising that the UK is not insulated from events in international energy markets (see Ellis et al, 2000; DTI,

2002). Nevertheless there is little doubt than the transformation of the industry since privatisation has played a major part in the favourable price trends indicated in figure 6.

3.2 Transport Costs, Gas Prices and Regional Development

The spatial structure of the gas supply system (see section 2.2), based on relatively few entry points (i.e. the coastal terminals and the inter-connector) and delivery to widely dispersed customers, implies a central role for transport costs. They are estimated to account for 25-35 per cent of a typical domestic gas bill (Energy Contract Company, 2004, 23; OFGEM, 2004, 2). These estimates, however, conceal significant place to place variations. A molecule of gas landed at St. Fergus in Scotland would, for example, take almost a day to reach Newlyn in Cornwall and require investment in approximately 65kms of pipeline. By contrast, the same molecule could be delivered to Aberdeen in under an hour over a pipeline length of 1,180 kms. Distance from the terminals is not, of course, the only factor contributing to spatial variations in the cost of transporting gas. Operating costs are much less sensitive to distance for the large diameter, high pressure pipelines of the NTS than for the smaller diameter, lower pressure pipelines of the DN. Continuing the hypothetical Newlyn-Aberdeen illustrations, the delivered cost of natural gas to a major industrial consumer with a high load factor in Cornwall may be lower than to a consumer with a small, irregular demand in Aberdeen. Thus delivery costs will vary both inter- and intra-regionally. Despite the self-evident point that costs of supply vary with location on the network, this was not reflected in the pricing policies of the state-owned BGC. Establishing a more transparent relationship between costs and prices has, however, been one of the key objectives of the regulators (first OFGAS and then OFGEM) following privatisation in 1986. In these circumstances, geography may be expected to become a more important variable in gas pricing.

This expectation is a logical consequence of the adoption of the principle of third party carriage via the Transco network. This principle was, as noted above (section 3.2), made a theoretical possibility in the 1982 Oil and Gas (Enterprise) Act, but not implemented until 1989 when OFGAS made the first of many attempts to devise a charging formula for users of the network. These attempts have been largely driven

by, on the one hand, pressure from large industrial/commercial consumers and, on the other, from suppliers wishing to serve them. A few suppliers use networks owned and operated by independent gas transporters, but the vast majority require access to the Transco network. The terms and conditions governing access to and use of this network have become central to efforts to promote competition through regulation. These terms and conditions must relate not only to the costs of operating the network, but, more importantly, must reflect an allowance for depreciation of investment already made as well as an incentive for investment in new capacity as required to meet demand.

The complexities of the accounting procedures overseen by the regulator and used to establish the payments made by shippers and suppliers for transportation services via the Transco network are beyond the scope of this paper (see Price, 1994; Easaw, 2000; Dixon and Easaw, 2001; Transco, 2004b; BP Gas, n.d.). What is of particular concern from a geographical perspective is the extent to which these payments and, more especially, the prices paid by consumers are influenced by the distance from reception terminal to final point of delivery (fig. 7). It is very difficult to answer this question because of the confidentiality of contracts to industrial/commercial customers. However, there is evidence that the significance of distance in Transco's gas transportation charges has varied as the charging formula has been periodically reviewed by the regulator since its introduction in 1989.

Contract and transportation schedules published in 1989 were a landmark in the efforts of OFGAS to force BG into making third party use of its network a realistic proposition following privatisation in 1986. These schedules were based on a per therm charge comprising two elements: a constant charge per therm and, significantly, a charge based on distance carried from beachhead terminal to offtake (Price, 1994). This charging structure, which remained fundamentally unchanged until the introduction of the Network Code in 1996 (see section 3.2), ensured that the opportunities for suppliers competing with BG in the industrial/commercial market were concentrated near to the coastal terminals. This was because BG continued to take no account of distance in its own schedule of prices for the supply of gas, allowing competitors to undercut its prices in areas where their carriage charges were low.¹⁰ The most obvious consequence of this exploited opportunity was a significant

burst of investment in CCGT power stations in relatively close proximity to the coastal terminals (see section 4.2).

In 1996, charges for third party use of the pipeline network changed to an entry/exit system. Under this system, users book entry and exit capacity on the NTS independently, allowing shippers to deliver gas from any input terminal to any exit zone. The coastal terminals are the principal entry points¹¹ and the UK is divided into eight regional exit zones (DNs) where capacity may be booked. This system gives shippers flexibility in sourcing their supplies and is essentially based on detailed measurement and allocation of gas flows at critical points on the NTS. This regime involves the specification of an hypothetical location (the National Balancing Point) at which account is taken of stock transfers of ownership. In contrast to the arrangements operating between 1989 and 1996, this procedure suppresses the influence of distance and inflates the cost of short-haul transmission via the NTS. Once gas passes from the NTS to the lower pressure DN systems, charges for its onward distribution within these regional systems are 'postalised', meaning that they are not dependent on customer location, but on load size which acts as a proxy for the distribution assets they use. Despite the adoption since the introduction of the Network Code in 1996, of a system of charging for third party use of the NTS and DN's which is less sensitive to spatial factors than under the system operating from 1989 to 1995, the most recent consultation exercise initiated by OFGEM (2004) explicitly draws attention to the question of making use of system charges more cost-reflective. This, in turn, suggests that these charges will be passed on to customers by shippers leading to the prospect of geographical variations in prices to final consumers. This on-going debate is, in a sense, an acknowledgement that the logic of increased competition implies the erosion of spatial cross-subsidies which have been a feature of natural gas supply in the UK ever since the late 1960s (Manners, 1997). Whilst subsidies may be anathema to hard-line free marketeers, their removal creates the potential to re-shape the geography of economic opportunity and to widen regional disparities in welfare. The extent of such changes remains speculative given the relatively recent introduction of significant competition in industrial/commercial and, especially, domestic markets. Nevertheless, some lessons may be learned by reflecting upon earlier regional development linked to the evolution of the natural gas supply industry in the UK.

4. SPATIAL PERSPECTIVES ON GAS SUPPLY AND CONSUMPTION

Although the share of UK primary energy consumption accounted for by natural gas is now comparable to that of coal a generation earlier, it has exerted nothing like the same influence upon the economic and social geography of the country. Coal mining created communities and regions as the coal fields became the dominant ‘clusters’ of the national economy. No equivalent contemporary clusters can be linked to natural gas apart from those, notably concentrated on Aberdeen, supporting production operations in the North Sea. Other visible onshore impacts are limited, with few exceptions discussed below, to the coastal terminals and transient construction activities associated with the development of the pipeline infrastructure. This infrastructure is one fundamental reason why natural gas has not had an impact upon the distribution of economic activity comparable to the historic significance of coal. In contrast to coal, the costs of transporting gas are low and the pipeline infrastructure allows efficient distribution across most of the UK. Spatial variations in the availability and cost of gas are very much less than those which drew energy-intensive industries such as iron and steel to the coalfields. Furthermore, this type of manufacturing is a much less important element of the modern, post-industrial economy. Nevertheless, natural gas is not available throughout the UK and it has already been argued that distance from the coastal terminals may become a more important factor in pricing policies (see section 3.3.). Some geographical implications of such considerations are reviewed below: first, the welfare consequences for regions without access to natural gas (section 4.1); second, the location of new CCGT power stations (section 4.2.); third, developments in energy-intensive industries (section 4.3.).

4.1 Access to Gas and Welfare

Energy is fundamental to the quality of human life and the proportion of household income spent on fuel for heat and light directly affects living standards. In the UK, for example, the official definition of ‘fuel poverty’ is a household “.....that needs to spend in excess of 10 per cent of household income on all fuel use in order to maintain a satisfactory heating regime” (DEFRA/DTI, 2001, 3). Since the share of

natural gas in domestic energy consumption has grown steadily to become by far the most important fuel (fig. 8), its availability and cost is obviously relevant to any assessment of the welfare implications of trends in the UK energy market.

The link between the rapid expansion of the pipeline infrastructure in the 1970s and the penetration of natural gas in this market has already been identified (see section 2.2.). Subsequent development of the infrastructure has been limited and approximately 4.5 million households in Great Britain (i.e. including Northern Ireland), 20 per cent of the total, do not have access to the mains gas supply (DEFRA/DTI, 2001, 19). This estimate incorporates 9,000 identifiable communities (DEFRA, 2004, 19). Transco has a statutory obligation to meet requests for connection from domestic consumers situated within 23m of an existing gas main. The costs of such connections are largely met by Transco, but the financial responsibility shifts to the customer beyond the 23m threshold.¹² This has obvious implications for the fuel options available to households in areas not served by the existing network. Table 2 indicates the number of communities of various sizes in these areas in 2001. A disproportionate share are concentrated in the more rural parts of the UK such as Wales and South West England. The large number of excluded communities in East Anglia is especially striking in view of the proximity of one of the earliest and largest gas reception terminals at Bacton.

The limited penetration of the gas network into rural areas reflects the unfavourable economics of pipeline systems serving small, widely-dispersed customers. Recent studies have attempted to calculate the costs of linking the settlements identified in table 2 to the NTS. (Working Group on Extending the Gas Network, 2001; Transco, 2002). Not surprisingly a cost-benefit analysis concluded that incorporating all of the communities and households currently excluded from the gas network would “.....not seem to be value for money” (Working Group on extending the Gas Network, 2001, para 12). There is, however, considerable variation in the position of these excluded communities and households relative to the network. The average cost of providing a connection is very sensitive to distance (estimated at £100 per metre plus £400 per household (Working Group on Extending the Gas Network, 2001, para. 12)) and almost 1,300 of the communities included in table 2 are within 2 km. of an existing gas main. Nevertheless, there has been little progress in extending the gas network

since the publication of the Working Group's report in 2001 (Fuel Poverty Advisory Group, 2003/2004). Thus the gas network remains 'national' in name (as the NTS), but not in geographical extent. Non-gas households must, therefore, use more expensive alternative fuels which have been estimated to increase their energy costs by 40 per cent (HC. 814, 2003, para. 10), contributing to a much higher incidence of fuel poverty in rural areas (DEFRA/DTI, 2003). Thus the restricted availability of gas is one of the multiple sources of rural deprivation in the UK. This syndrome is mainly expressed by reference to the quality of domestic life, but it is worth noting that higher energy costs, aggravated by the absence of competition from gas, may also limit rural business opportunities.

Although the 20 per cent of UK households without access to natural gas tend to face higher energy costs than the remaining 80 per cent connected to the pipeline network, it has already been noted that the privatisation project has contributed to a general fall in energy costs. (see section 3.2). However, these benefits have not been shared equally. Various studies of consumer behaviour have suggested that the better off gain more from attempts to promote competition in regulated utilities (Burns et al, 1996). This not only reflects their greater awareness of the opportunities to switch from higher- to lower-priced suppliers, but also the nature of these opportunities. For example, financial incentives are offered by gas suppliers to customers paying their bills by direct debt. By contrast, the higher costs of providing and servicing pre-payment meters, which tend to be the preferred method of payment for those in the lower income categories, are passed on to the consumer using them (Waddams Price and Bennett, 1999). It is possible that these differentials may widen if new suppliers challenge the still dominant position of BG Centrica in the domestic market by targeting the most attractive customers (i.e. those combining high levels of consumption with reliable records of payment). Thus "The majority of gas consumers seems likely to benefit from competition but for a small and particularly vulnerable group competition may cause significant difficulties" (Waddams Price, 1997, 60). This prediction emphasises that the distributional consequences of the privatisation of the gas supply industry may be social as well as geographical. The Utilities Act 2000, whilst explicitly equating ".....the interests of consumers.....[with] the promotion of effective competition", at the same time acknowledges that this assumed causality may not be universally benign in its effects by granting powers to the Secretary of

State to adjust the charges of transporters, shippers and suppliers to protect the interests of disadvantaged consumers.

4.2 Gas and Electricity Generation

It has already been noted that the power station market was the principal factor contributing to the increasing share of natural gas in UK primary energy consumption during the 1990s (see section 2.1). Peterhead was the only gas-fired power station in 1992, but 22 were operational by the winter of 1996/97. Despite the imposition of a moratorium on planning consents for new gas-fired stations at the end of 1997, prompted by concerns for the future of existing coal-fired stations and for the long-term security of gas supplies, 33 CCGT stations are operational in 2004, representing 31.3 per cent of UK installed capacity (fig. 9). Taking account of dual-fired stations, natural gas accounted for 32.3 per cent of the fuel input (expressed in tonnes of oil equivalent) used to generate electricity in 2003 (DTI, 2004). The corresponding figure in 1992 was 0.7 per cent. Whatever measure is used, it is clear that the last 10 years have witnessed a headlong ‘dash for gas’ in electricity generation (see Spooner, 1995; Manners, 1997).

Several factors have contributed to this development. The technology of combined-cycle gas turbines (CCGT) offers many advantages; it has a higher thermal efficiency than traditional stations fired by coal and oil; capital costs per unit of output are low; construction times are short; and incremental additions to capacity are relatively easy. One of the most significant benefits of CCGT technology derives from the relatively low emissions of atmospheric pollutants associated with burning natural gas. In particular, virtually no sulphur dioxide is emitted from gas-fired CCGT stations – a characteristic which is attractive both to the electricity supply industry, because it reduces the liabilities to retrofit expensive flue gas desulphurization equipment to existing coal-fired stations, and to government, because it will help the UK to meet its international treaty obligations to reduce sulphur dioxide emissions. Indeed, the regulatory environment surrounding the operation of power stations in the EU seems likely to reinforce the attractiveness of gas-fired plants. Carbon emission trading will commence in 2005 and although this will have some adverse effect on gas-fired power stations, it will have a much greater effect on coal-fired ones. More

significantly the EU Large Combustion Plant Directive will start to come into force from 2008, restricting the operation of coal-fired generating plants without flue gas desulphurisation.

The 'dash for gas' has not only been driven by the technical advantages of CCGT power stations. Organisational changes in the gas and electricity supply industries linked to privatisation (see section 3.2) also contributed as a result of the coincident commercial interests of the purchasers and suppliers of gas. As previously noted (section 3.3.), new competitors to BG were able to undercut its prices in the industrial/commercial market and this stimulated considerable interest in long term contracts by the regional electricity companies. Their interest was reinforced by the desire to reduce their dependence upon the dominant generators. The regional electricity companies have, therefore, taken equity interests in various independent power producers whilst the established generating companies such as Powergen responded by building their own CCGT stations.

The effect of these developments upon the geography of electricity generation in England and Wales are evident in fig. 10.¹³ Three locational tendencies can be identified. First, several of the largest CCGT plants are near to the coastal landfalls from offshore fields. Second, others are adjacent to main trunk pipelines on the NTS. Third, most of the remainder are situated within the major electricity market of South East England. Overall, the 'dash for gas' has significantly weakened the traditional geographical association between the coalfields and the power stations (most clearly seen in the concentration of capacity along the valleys of the Aire, Calder and Trent in South Yorkshire and the East Midlands). The coastal locations of CCGT stations such as Teesside, Killingholme and Connahs Quay could be regarded as the contemporary equivalent of the coalfield link as the costs of supplying gas are reduced by the proximity of these stations to the entry points to the Transco network and to pipelines operated by independent gas transporters.

Viewed at the national scale, the 'dash for gas' has had major effects on the UK energy market. The direct economic impacts of the new power stations at the regional scale has, however, been limited. They are capital-intensive operations and the electricity they produce is normally fed into the national grid. In a few cases, they

have been viewed as key assets in attempts to promote clusters of energy intensive industries (see section 4.3), but the most significant regional development consequences of the spectacular growth in the contribution of natural gas to the generation of electricity in the UK have been indirect. The power station market has been fundamental to the survival of the coal industry in the UK and successive governments have intervened in ways which have variously strengthened or weakened the place of coal in this market (see Chapman, 2000). Such intervention is difficult to reconcile with the 'free market' logic of privatisation. The 'dash for gas' reflects this logic. By displacing coal-fired capacity, CCGT power stations could be regarded as the penultimate 'nail in the coffin' of an industry which exerted a profound influence upon patterns of regional economic development in the UK (Sadler, 2001).

4.3 Gas and Energy-Intensive Industries

Industry (excluding the energy industries¹⁴ and electricity generation) accounted for 16.5 per cent of total UK gas consumption in 2003 (DTI, 2004). The chemical industry used almost one-third of this followed by food/beverages (15.2 per cent of industrial gas consumption), iron/steel (10.4 per cent) and paper/printing (8.5 per cent)(DTI, 2004). This ranking is influenced by the relative importance of these sectors within the UK economy as well as by the significance of gas for their operations. The most energy-intensive processes, in which energy costs are a key influence upon total costs, are associated with commodity chemicals, iron and steel, paper- and glass-making. These industries are typically dominated by large multinationals which respond to competitive conditions at the international scale. However, they also take a strong interest in the availability and cost of energy within individual countries. More specifically, any influences upon industrial investment and location decisions related to the expanding role of natural gas in the UK energy market may be expected to be most apparent in the energy-intensive industries.

Natural gas is both a source of energy and a raw material in the chemical industry. The volumes directed to these two types of use in the UK in 2003 were in a ratio of 4:1 respectively (DTI, 2004). Despite the much greater volumes of gas used to generate heat for thermal processes, it was the potential of natural gas as a feedstock for the manufacture of products such as methanol, ammonia-based fertilisers and,

especially, a wide range of petrochemicals used in plastics and numerous other downstream derivatives, which attracted the greatest interest. Specific proposals to establish a gas gathering system to collect ethane from many fields and deliver it to coastal terminals for onward transmission to chemical sites were published in 1976 (Williams-Merz, 1976). Established petrochemical producers in the UK were keen to connect their existing sites to these delivery systems, whilst others considered developing new sites. For a time, it seemed that access to North Sea ethane would offer important competitive advantages leading to a much larger UK petrochemical industry exporting to the rest of Western Europe (Chapman, 1977). In the event, only one greenfield site was developed when Shell and Esso established a jointly owned ethylene plant at Mossmorran in Fife. Downstream developments at this site have been very limited and its output is transferred for further processing to long-established complexes elsewhere in the UK and mainland Europe. Thus speculation that North Sea gas would re-shape the geography of the petrochemical industry in the UK and, by implication, in Europe has proved wide of the mark.¹⁵ These predictions had assumed a continuation of the industry's spectacular growth, but the new feedstock became available at a turning-point in its evolution (Chapman, 1991). Restructuring and retrenchment were the norm in Western Europe throughout the 1980s and investment opportunities in this essentially mature (in Europe) industry are limited.

The possibility that the coastal terminals might attract investment in energy-intensive industries such as mineral smelting and chemicals was raised at an early stage in the exploitation of North Sea gas (Odell, 1968) and formally recognised in contemporary planning reports (see Northern Economic Planning Council, 1966; Yorkshire and Humberside Economic Planning Council, 1966). These were conceived as industrial complexes, fundamentally based on the availability of cheap gas, bound together by input-output relationships between functionally linked activities. This vision of an 'East Coast Gasopolis boom' (Odell, 1968) was influenced by the prevailing popularity of the growth pole/centre as the dominant model for regional development. This geographically-focused 'boom' of energy-intensive industries, like the corresponding forecasts of feedstock-driven growth in petrochemicals, failed to materialise. Although potential petrochemical projects were generally unaffected by the pricing policies of BGC because they used components (mainly ethane and

propane) extracted from the landed gas in processing plants operated by the producers at the terminals before it entered the NTS, other industrial customers were obliged to buy gas from the state-owned monopoly supplier. It has already been observed (see section 3.2) that the prices charged by BGC were not directly related to the costs of supply, thereby eliminating the potential benefits for energy-intensive consumers of proximity to the terminals. Furthermore, events in international energy markets in the 1970s made locations in Western Europe much less attractive to large-scale energy-intensive industries than in oil- and gas-rich countries in the Middle East and elsewhere. Thus the kind of gas-based industrialisation which some anticipated along the East Coast of England has occurred in places such as Indonesia, Trinidad and Saudi Arabia (Auty, 1990).

There has been a recent revival of interest in energy- and, more specifically, gas-based economic development in the UK at the local scale. For example, CCGT power stations are central features of an ‘energy park’ at Baglan Bay in South Wales and of efforts to promote Wilton on Teesside as “a world class manufacturing site which welcomes chemical and other high energy process operators” (Wilton International, n.d.). In addition to their power stations and associated infrastructure, the unifying feature of Baglan Bay and Wilton is their status as former (Baglan Bay) and declining (Wilton) petrochemical complexes. Their promotion is, therefore, based more on hope than expectation of success. Furthermore, such initiatives owe more to the ‘old economy’ models of geographically-focused development based on the exploitation of physical linkages than to the currently fashionable cluster concept with its emphasis upon information-based relationships and innovation (Chapman, In press). On a broader level, there is no evidence in the UK, with the significant exception of the petrochemical industry, that the availability of natural gas either has been or will be a decisive factor in the evolution of distinctive regional clusters of economic activity. The only reference to gas in a comprehensive, government-funded attempt to produce a “.....map of cluster-related activity across the UK” (Trends Business Research, 2001, 2) concerned the activities supporting oil/gas *production* in the North Sea.

5. CONCLUSIONS

The introduction of natural gas from the North Sea into the UK energy market has clearly had major consequences at the national scale. It rapidly displaced the town gas industry, superimposing a national distribution system upon the local and regional systems which dated back to the 19th C. It also displaced other fuels, notably coal, in many markets and its growth has been the principal factor shaping to the very different mix of fuels contributing to UK energy consumption in 2004 compared with 1967 when North Sea gas was first landed in England. At a macro-economic level, the UK has clearly benefited in many ways from the ‘windfall’ of North Sea oil and gas. These benefits have found clearest regional expression in the transformation of the economic fortunes of North East Scotland, particularly Aberdeen, as the focus of the North Sea oil and gas industry. At the opposite end of the spectrum of economic experience, the decline of the coal industry, certainly accelerated by the rise of natural gas, has destroyed entire communities and left an enduring legacy of economic and social deprivation in several parts of the UK. Ironically, this legacy is, perhaps, the clearest regional economic impact deriving from the consumption of natural gas, albeit an indirect one. The rapid development of the NTS for the delivery of natural gas to most parts of the UK and, certainly, to the principal centres of population and economic activity, reduced the scope for spatial variations in its availability to modify the familiar, established outlines of the country’s human geography. Natural gas rapidly became a ubiquity to consumers in all but the remoter, rural communities and regions. On the other hand, it is likely, although impossible to demonstrate, that improvements in the position of several parts of rural Britain relative to the urban-oriented majority have been harder to achieve because of their exclusion from what has become the fuel of choice for the overwhelming majority of households and, to a lesser extent, for industrial/commercial consumers as well. The fact that natural gas prices, for most of the period since the first deliveries in 1967, displayed no systematic spatial variation reflecting the underlying costs of transportation (including capital cost recovery on the infrastructure) from the terminal inputs to the NTS, has been another important reason suppressing the emergence of regional differences in economic opportunity linked to the use of natural gas. Paradoxically, the distribution of the new CCGT power stations, which does seem to have been influenced by such

considerations, serves to emphasise the importance of the historic exclusion of transport cost, broadly defined, from pricing policies. It also draws attention to the as yet uncertain long term impact of moves towards cost-based pricing arising from recent developments in the regulatory environment.

Notes :

1. This national system became part of a European network with the completion of pipeline links to Ireland and Belgium in 1995 and 1998 respectively.
2. Primary energy consumption takes account of fuels used in the generation of electricity (excluding nuclear and hydro).
3. It is worth noting that, as a result of purchases of Norwegian gas from Frigg, natural gas imports rose to a peak of over 25 per cent of UK consumption in 1985.
4. Transco is required to operate its network as a 'common carrier' of gas. The background to this obligation is discussed in sections 3.2 and 3.3.
5. The NTS is also linked to networks in mainland Europe via the Zeebrugge inter-connector.
6. These practices were discriminatory in the sense that prices were shaped less by the costs of delivering gas and more by the options available to consumers for switching to alternative (non-gas) energy sources.
7. OFGAS was established as the regulator for the gas supply industry in 1986. This was combined with the equivalent agency for the electricity supply industry (OFFER) in 1999 to establish OFGEM. From 2000 OFGEM was itself required to report to the Gas and Electricity Markets Authority (GEMA) and the Gas and Electricity Consumers Council (GECC).
8. BG Transco became Transco in 2000.
9. The other major players are Total (23 per cent), Powergen (14.2 per cent), Shell Gas Direct (13.7 per cent), BP Gas (11.5 per cent) and GdF (10.9 per cent)
10. This development should be seen in the context of an office of Fair Trade ruling in 1991 that BG should, in the interests of promoting competition, surrender a substantial proportion of its bulk (i.e. customers purchasing over 25,000 therms per year) by 1995.

11. Others include three small on-shore fields and seven gas storage sites.
12. Such customers do not necessarily have to meet the full connection costs by making an up-front payment. Costs may be recovered over a larger period by levies applied to gas bills.
13. There has been virtually no new investment in gas-fired capacity in Scotland despite the fact that the St. Fergus terminal receives a larger share of landed gas than any other. Several factors are responsible for this including a long-established surplus of generating capacity relative to electricity demand in Scotland.
14. Mainly oil and gas production in which significant quantities of natural gas are consumed offshore.
15. The establishment of the Norwegian petrochemical industry using material from Ekofisk delivered to Bamble via the Teesside terminal in the UK was the exception.

Table1: Chronology of key legislation and principal agencies/institutions in privatisation of UK gas supply industry

YEAR	LEGISLATION	AGENCIES / INSTITUTIONS
1982	Oil and Gas (Enterprise) Act	
1986	Gas Act	British Gas Plc Office of Gas Supply (OFGAS)
1992	Competition and Service (Utilities) Act	
1995	Gas Act	
1997		BG Plc Centrica
1999		BG Transco Plc Office of Gas and Electricity Markets (OFGEM)
2000	Utilities Act	Gas and Electricity Markets Authority (GEMA) Gas and Electricity Consumers Council (GECC)
2002		National Grid Transco Plc

Table 2: Communities outside the gas network

Region	Settlements >150 dwellings	Settlements >300 dwellings	Settlements >750 dwellings
East Anglia	729	217	17
E. Midlands	248	60	3
N. London	39	8	0
North	237	85	7
North West	94	23	2
Scotland	281	131	13
South-East	191	63	4
South	568	183	16
South-West	799	318	31
Wales	396	139	8
W. Midlands	301	82	4
Yorkshire	134	32	0
TOTAL	4017	1341	105

Source: Working Group on Extending the Gas Network, 2001, para 3.

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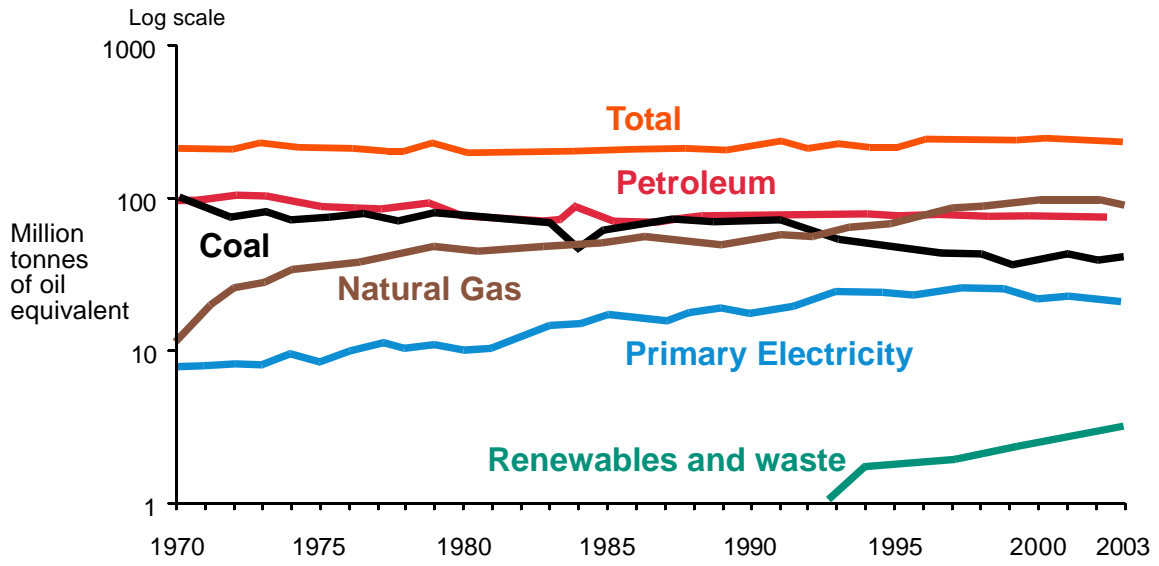
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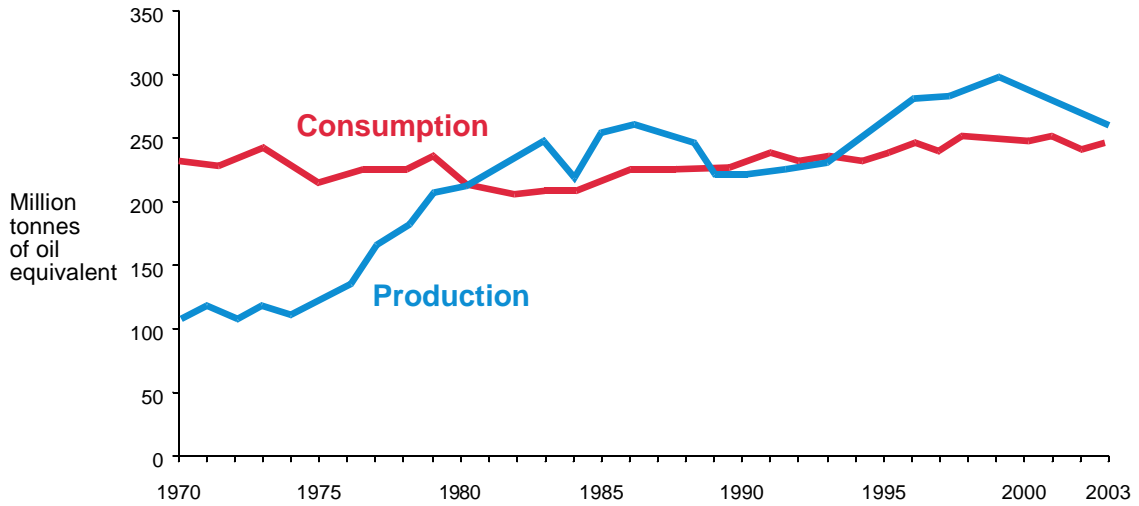
1. UK primary energy consumption 1970–2003. Source: DTI (2004)
2. UK energy production and consumption 1970–2003. Source: DTI (2004)
3. UK consumption of natural gas 1970-2003. Source: DTI (2004)
4. Development of UK national transmission system (NTS) 1967-2003. Sources: Annual reports of Gas Council (1970), BGC (1980), BG (1990), DTI (2004).
5. Structure of UK natural gas supply industry.
6. UK domestic and industrial energy prices 1980–2003. Source: DTI (2004)
7. Gas transportation system.
8. UK domestic energy consumption by fuel 1970-2003. Source: DTI (2004)
9. UK fuel input for electricity generation 1993–2004. Source: DTI (2004)
10. Electricity generating stations in England and Wales, 2004. (>250MW installed capacity only).

Fig 1: UK Primary Energy Consumption



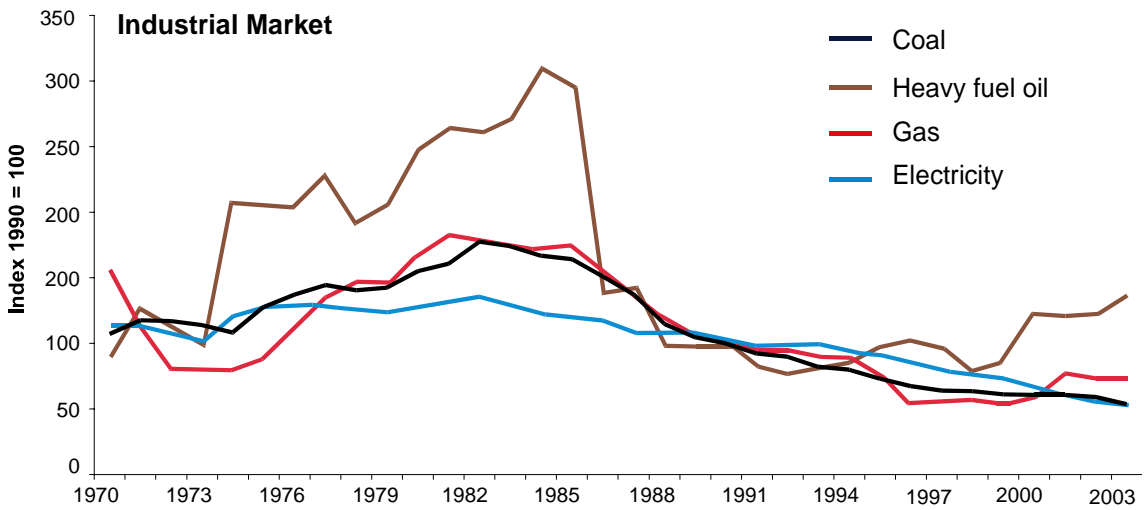
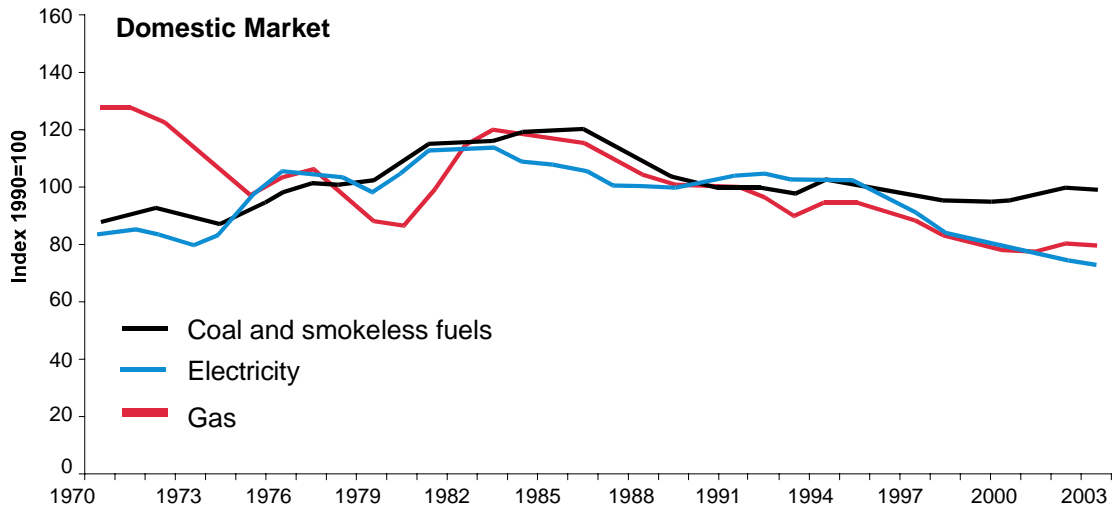
Source: DTI (2004)

Fig 2: UK Energy Production and Consumption



Source: DTI (2004)

Fig 6: UK Energy Prices



Source: DTI (2004)

Fig 5: Structure of UK Natural Gas Supply Industry

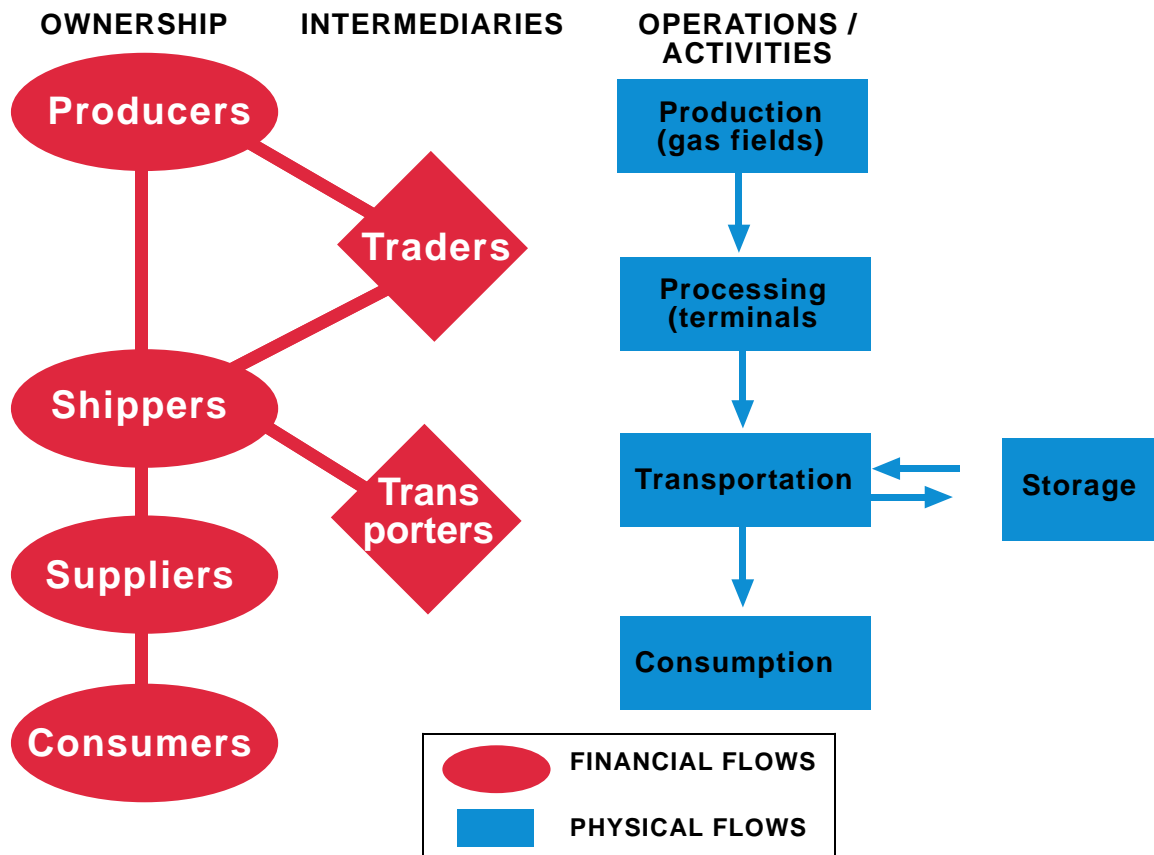


Fig 7: Gas Transportation System

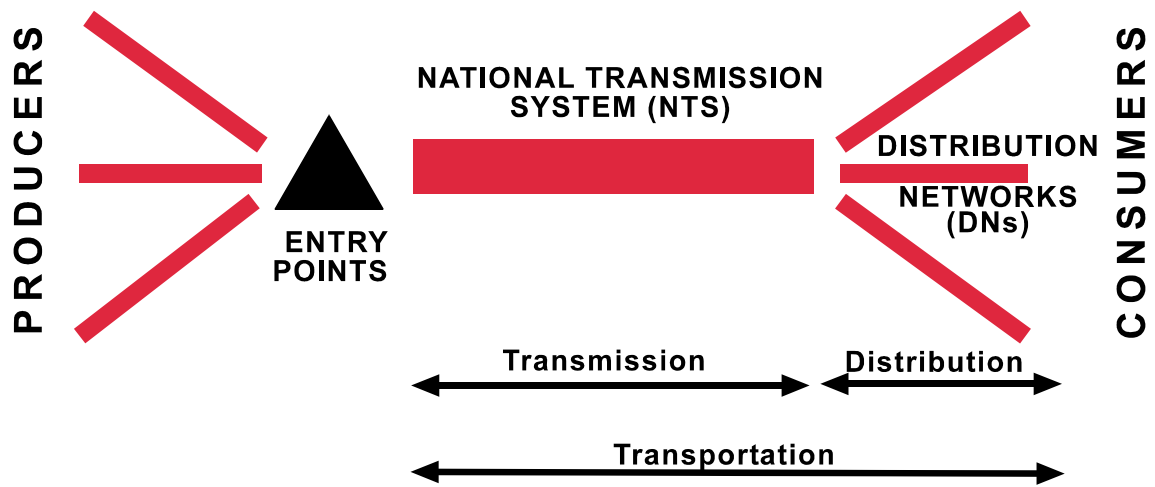


Fig 3: UK Consumption of Natural Gas

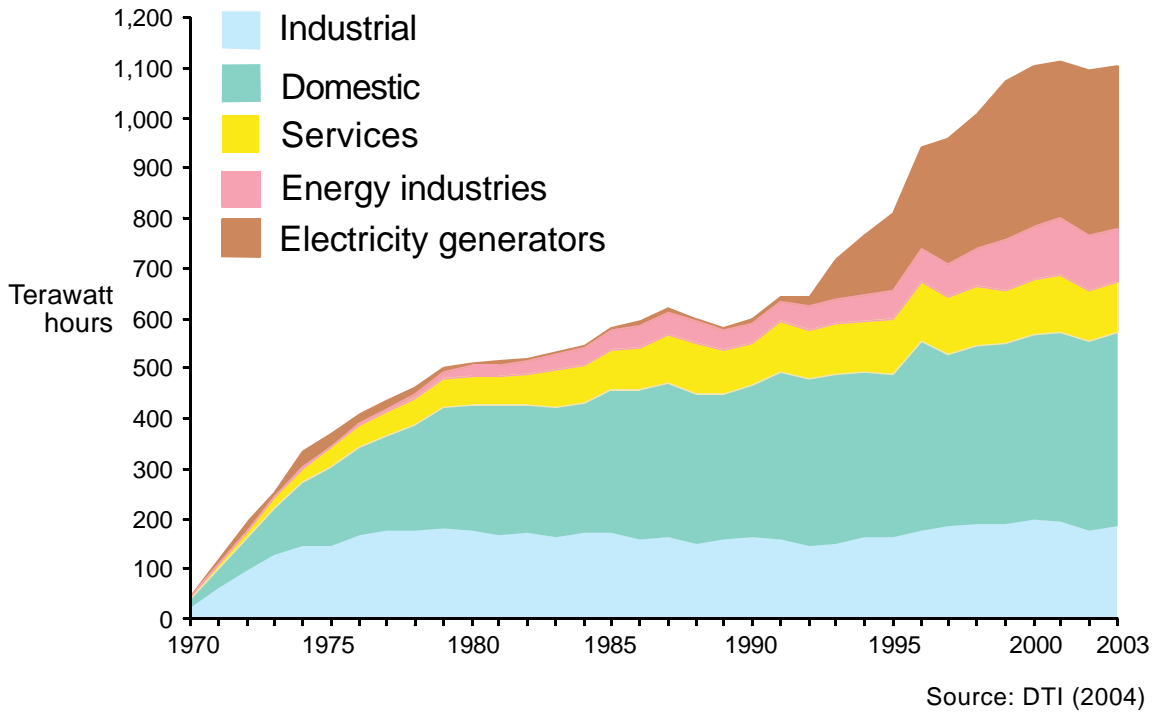


Fig 9: UK Fuel Input for Electricity Generation

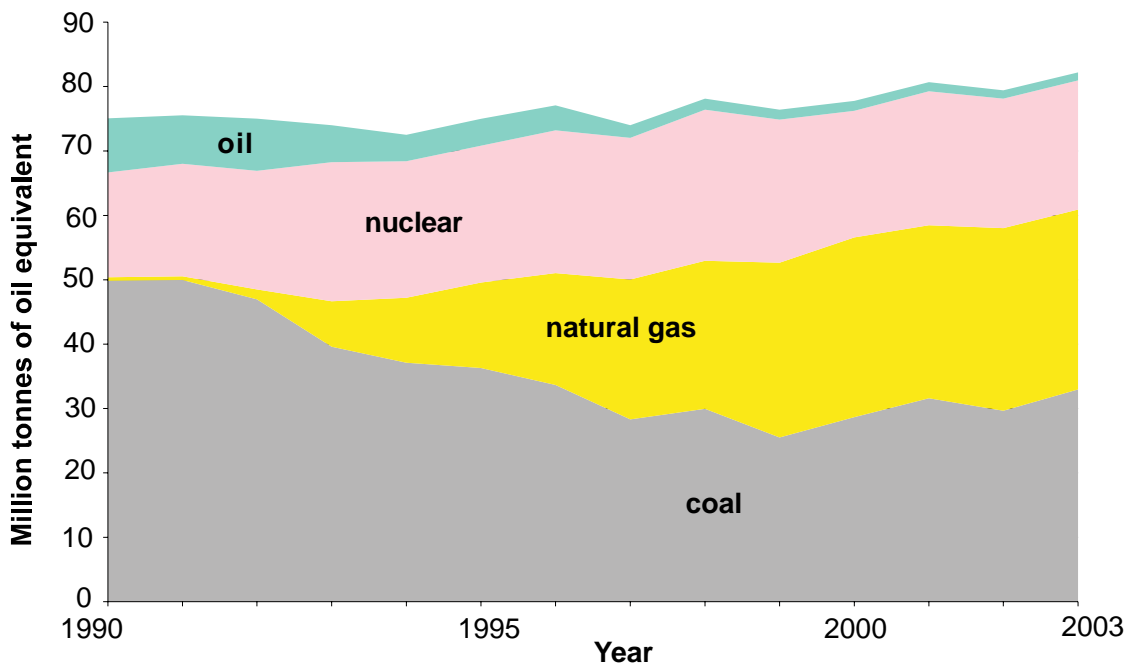


Fig 4: Development of National Transmission System

